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# Key lessons from Indigenous Peoples and Local Communities' farming systems: insights from a global review

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Indigenous and traditional farming systems, used and practised by the Indigenous Peoples and Local Communities (IPLCs), over millennia, offer viable, secure, and diverse solutions to many problems caused by the modern agricultural systems, such as soil and water pollution with excessive input of chemicals, water usage, and heavy dependence on a few crop varieties globally, leading to severe environmental consequences. We reviewed 49 studies from various regions, encompassing a range of geographic areas, from mountainous to arid agro-ecological systems, and highlight the diverse farming techniques applied by the IPLCs. The key attributes of IPLCs' farming systems include their diverse, holistic, and intertwined nature of land, water and people, which integrates site-specific local knowledge, cultural values, rituals, and social festivals—offering multiple benefits for both human and ecosystem health. However, due to non-monetary nature of many such benefits, their true value largely remains underestimated or ignored. Only 24 out of 49 reviewed studies highlighted the economic value of these systems, which was limited to the monetary value of produce while omitting a significant non-monetary component. We suggest applying a TEEB (The Economics of Ecosystems and Biodiversity) agri-food systems approach, accounting for natural, social, human, and produced capitals, to inform policy decision-makers so that IPLC farming systems are appropriately supported in the future. In addition, these systems are often grounded in community settings, with local governance and fine-scale local knowledge (as revealed in all studies), and they can deliver community-led initiatives, social cohesion, and effective local solutions to environmental problems, such as biodiversity loss and soil degradation. However, due to colonization, industrialization, agricultural expansion, and market pressures, these farming systems are facing serious challenges. This paper highlights the ecological, social and economic importance of IPLCs' farming systems—suggesting the need for governments to revive, promote and support them to ensure food security, the health and nutritional well-being of people, and the health of natural systems for the present and future generations. Learning IPLC' agroecological, socio-cultural, and sustainability principles can help update modern agricultural systems.

KEYWORDS

**Indigenous ecological knowledge, indigenous farming systems, indigenous practices, sustainable agriculture, traditional farming systems**

## 1 Introduction

Agriculture is critical to maintaining global food production, the economy, and food security for the growing population (McKenzie and Williams, 2015). Globally, agriculture uses approximately 40–50% of the land area; most of this use has resulted from clearing one-third of the forest land and two-thirds of the wild grassland (Ritchie, 2021). Human pressures to develop land for agriculture have continued to date, with an average of 5 million hectares cleared per annum (between 2000 and 2020). Notably, 95% of this clearing has occurred in the tropics, and 70–75% of total clearing has been primarily for agricultural purposes (Ritchie, 2021). In the past, most agricultural expansion occurred through the large-scale clearing of grasslands, savannas, and forest systems in tropical and temperate regions (Goldewijk, 2001; Foley et al., 2011; Gibbs et al., 2010), whereas recent development is largely limited to the tropics. To achieve food security for the projected 10 billion people by 2050, there is a need for a 35–56% increase in food production while halting any further land clearing and land use change; thus, requiring the development of efficient food systems to meet the increased demand (van Dijk et al., 2021). In this pursuit, any future agricultural expansion has constraints, not least but mainly due to limited and available arable/fertile areas for cultivation and land degradation associated with soil erosion, lack of fertility, salinization, waterlogging, and climate change variability, suggesting the need for new sustainable ways of farming. One such important pathway is to learn from and adapt millennia-old, diverse, and sustainable food systems and practices developed and practised by Indigenous Peoples and Local Communities (IPLCs) across the globe.

Since the 1950s, with the onset of the Industrial Revolution, modern agriculture has undergone rapid evolution, driven by the Green Revolution, which aimed to increase yields of cereal crops using chemical inputs and improved varieties (Pingali, 2012). The genetic improvement of crop germplasm characterized with short-maturity time/harvesting enhanced the productivity of wheat, rice, maize, potatoes and cassava in developing countries during 1960–2000 (e.g., an increase of 208% for wheat, 109% rice, 157% maize, 78% potatoes, and 36% for cassava production in developing countries) (Food and Agriculture Organisation (FAO), 2004). These rapid increases in agricultural yields per hectare have been made possible through intensive cropping, the use of chemicals and the over-exploitation of land and water resources. On the one hand, the adoption of modern varieties and the intensification of agricultural systems have increased the global food supply, thereby preventing the conversion of thousands of hectares of land into agricultural land. On the other hand, this intensive cropping practice predominantly relies on the availability of high-yielding varieties of seeds, chemical fertilizers, irrigation, and pesticides, among others, contributing to serious environmental and human health problems (Figure 1; Gamage et al., 2023; Intergovernmental Panel on Climate Change (IPCC), 2023; Poore and Nemecek, 2018; Foley et al., 2011; Gibbs et al., 2010). For example, globally, 26% of total greenhouse gas (GHG) emissions come from food systems (Poore and Nemecek, 2018; Figure 1), occurring mainly due to tenfold increases in fertilization and groundwater use, as well as more than a doubling of mechanized and irrigated areas (Abdo et al., 2024; Ritchie et al., 2022). Similarly, the health impacts of heavy use of chemical fertilizers and pesticides are now well documented on vector-borne diseases, overweight and malnutrition, neurological disorders, respiratory and reproductive disorders (especially due to pesticide toxicity), in addition to leading to inequity in development (Zhou et al., 2025; Sarkar et al., 2012).

The mainstream/modern cropping system focuses on a narrow range of crop species (e.g., rice, wheat, maize) and genetic diversity, while transforming the whole ecosystems to simpler and highly

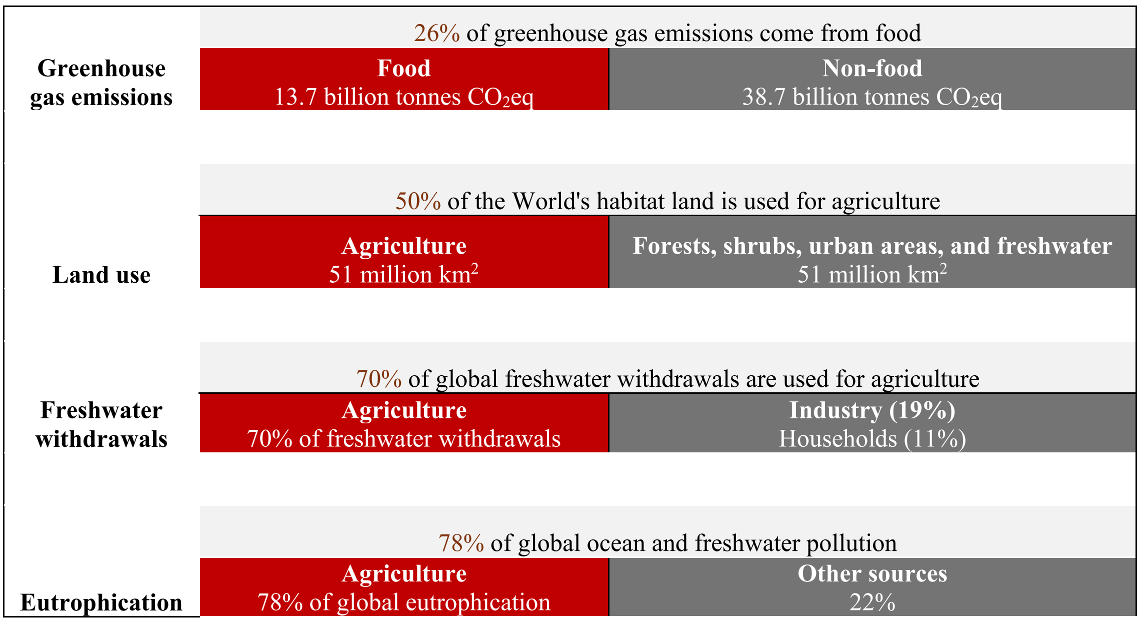


FIGURE 1
The environmental impacts of modern farming systems (Source: Our World in Data, 2025: https://ourworldindata.org/environmental-impacts-of-food#key-insights [originally adapted from Poore and Nemecek, 2018]).

intensive forms of land use (Koohafkan and Altieri, 2011). Such simplification of the agroecosystem has been criticized for reducing the complexity and diversity of agroecosystems, thereby disrupting the natural balance of water, nutrient, and energy flows. The ecological impacts of abandoning traditional practices have led to a serious decline in agrobiodiversity and nutritional values, resulting in increased susceptibility to plant pests and disease problems in many modern agroecosystems, as well as a lower ecological buffer against changing climatic conditions, further adding to social and health issues (Abdo et al., 2024; Puneeth et al., 2024; Zimmerer and de Haan, 2017). Socially, modernization of agriculture has led to disruptions of traditional food systems, practices, knowledge, socio-cultural fabric of farming communities, land scarcity, and insecurity of ownership rights, particularly for millions of smallholder farmers across the globe who could not maintain productivity at the farm scale in the marginal environment (Asai and Antón, 2024). Even though today the agricultural productivity has increased for major crops, mainly rice, wheat, and maize;, smallscale farmers, including IPLCs, face serious problems of access, security, and decline in diverse and nutritious foods (Zimmerer and de Haan, 2017; Asai and Antón, 2024; FAO, 2021).

With increasing concerns about global biodiversity loss and climate change, a shift in the agricultural paradigm is necessary to preserve biodiversity, water resources, and soil fertility while meeting the nutritional needs of a growing human population (Gomiero et al., 2011; Hummer and Hancock, 2015; FAO, 2024). Modern agricultural systems must integrate biological and ecological processes into the food production process to minimize the use of agrochemicals that harm the environment, protect the agrodiversity in the Vavilonian centres for resilient, nutritious and sustainable crops in the future, and the health of farmers and consumers. Moreover, modern mechanized systems have disrupted the socio-cultural network and local knowledge that have existed over millennia in many farming communities across the globe (Cairns, 2007). Substituting human capital for costly external inputs and machinery in highly populated, agriculture-dominant countries such as India, China, Pakistan, and Bangladesh, while contributing to health, social, and environmental problems, seems a deplorable and irrational economic option. Instead, making productive use of people's collective capacities to work together to solve common agricultural and natural resource problems (e.g., monoculture of food systems, heavy use and pollution of water and land), while producing nutritious and sufficient food, can help deliver multiple benefits (Sangha, 2014; Cairns, 2007; Pretty, 2008; FAO, 2021). In response to those challenges, traditional farming practices can help shift modern agriculture from over-reliance on mechanical and external inputs to food systems with diverse and nutritious crop varieties. The fundamentals of traditional farming system encompass local-scale, fine knowledge of crop and animal varieties, and native forms of sociocultural organisation, which offer promising models for diversified agro-ecological and sustainable food systems requiring little/no agrochemicals (Denevan, 1995; FAO, 2021; FAO, 2024).

The IPLCs' agroecological systems can help advance agricultural innovations as their cultural, ecological, and agricultural diversity is still evident in many parts of the world. Nearly 5 million hectares of traditional agroecosystems (e.g., raised fields, terraces, polycultures, and agroforestry systems) exist worldwide, contributing to sustain year-round yields, cultural heritage, and ecosystem services on local to global scales (Altieri, 2004). Many such farming systems are recognized under the FAO initiative on Globally Important Agricultural Heritage Systems (GIAHS; https://www.fao.org/giahs/en), where intricate relationships between people and land have continued to date. Traditional agroecosystems of IPLCs evolved in tandem with biological evolution and ecosystem function, characterized by genetic diversity that occurred without external inputs, capital, or scientific knowledge. IPLCs utilize their experiential knowledge to sustain yields and maintain diverse food sources with readily available micronutrient-rich foods. IPLCs knowledge over generations helps them to learn and adapt to local/place-specific environmental, climatic, and physiographic conditions (Armstrong et al., 2021; FAO, 2021).

We use the terms 'Indigenous' and 'traditional' to describe farming systems that have been developed and practised by both Indigenous peoples, and local communities, utilising their knowledge, cultural values, norms, practices, transmission modes, and belief systems. Our rationale is that many local communities across Asia and Africa (both host important Vavilonian centres of agrodiversity) have been practising sustainable, traditional farming for millennia; however, a majority of them are not formally recognized as Indigenous (Ahammad et al., 2026). Leaving them out means leaving a significant proportion of practitioners who have practised traditional farming for millennia. Therefore, we use the terms Indigenous, traditional, and IPLC farming systems interchangeably in this paper.

We describe the IPLCs' agricultural practices, benefits, challenges and threats by reviewing 49 studies that cover all geographical regions, with a dominant representation from Asia, followed by Latin America and Africa. We highlight the key characteristics of IPLCs' farming systems and outline their role in informing modern agriculture. We anticipate that collating IPLCs' farming systems-related knowledge and practices can help inform current agricultural practices to create sustainable, diverse, and healthy food farming systems. In doing so, the IPLCs, along with their systems, can also be respected, preserved, advanced, and supported for the benefit of both present and future generations.

## 2 Methods

In April 2025, we conducted a comprehensive literature search focusing on Indigenous farming systems. To capture a wide range of relevant studies, we developed a set of structured search queries and retrieved publications from the Scopus database. The search incorporated combinations of keywords such as *"Indigenous community" OR "Indigenous people" AND "agriculture"*; *"indigenous practices" OR "traditional ecological knowledge" AND "agriculture"*; *"indigenous agricultural systems"*; *"traditional agriculture" AND "agrobiodiversity" OR "indigenous knowledge" "traditional knowledge"*; and *"traditional farming."* The search was restricted to peer-reviewed journal articles and book chapters, yielding a total of 49 documents that met our inclusion criteria, specifically: (i) the type of traditional/indigenous farming practices; (ii) the value of produce (both monetary and non-monetary), and (iii) Related challenges.

Our review was guided by the PRISMA 2020 framework following Page et al. (2021). Before screening the literature, we established three guiding scopes that shaped our analysis: the types of Indigenous farming practices documented; the key benefits reported, including contributions to food security, nutrition, and livelihoods; and the primary drivers and motivations underlying these practices, whether market-based, cultural, or ecological. We also recorded the dominant crops or species highlighted across the studies to identify overarching patterns within Indigenous agricultural knowledge.

We systematically screened the titles, abstracts, and full texts of the retrieved publications to identify studies relevant to Indigenous farming systems (Figure 2). The screening process followed three sequential stages: title screening, abstract screening, and full-text review. Only studies published in English between 2018 and 2025 were selected. To ensure comprehensive coverage, we also conducted a supplementary Google search to capture relevant articles not identified through the Scopus database, which resulted in the addition of 22 publications. In total, 49 studies met our inclusion criteria (Figure 2). Eligible studies examined traditional or Indigenous knowledge and practices in farming systems, referenced Indigenous peoples and/or local communities (IPLCs), explored the market and non-market values of agricultural products, or discussed the challenges and barriers associated with practising Indigenous or traditional farming. From each selected study, we extracted key information, including the year of publication, the Indigenous or local groups involved, the types of farming practices documented, the primary benefits reported (e.g., food, nutrition, or livelihood support), the main drivers and motivations (market-based, cultural, or ecological), and the dominant crops or species highlighted.

In addition, our research drew on some seminal global publications on IPLCs' food and farming systems, such as those from the FAO, as well as others that highlight the issues associated with modern agriculture.

## 3 Results

This review synthesised findings from 49 peer-reviewed studies published between 2018 and 2025 that documented the Indigenous and traditional farming systems, practices, and knowledge across diverse geographic regions and ecological contexts. The reviewed literature represents a growing body of research attention to these agricultural systems, with a notable increase in publications in recent years: six studies were published in 2018–2019, 10 in 2020–2021, 22 in 2022–2023, and 11 in 2024–2025. This temporal pattern reflects increasing scientific and policy interest in understanding how traditional knowledge and practices can inform mainstream agriculture and help address contemporary challenges, including climate change, biodiversity loss, and food security.

### 3.1 Geographic distribution and regional representation

The reviewed studies encompassed research conducted in almost all continents, with particularly strong representation from Asia, the Americas, and Africa (Table 1).

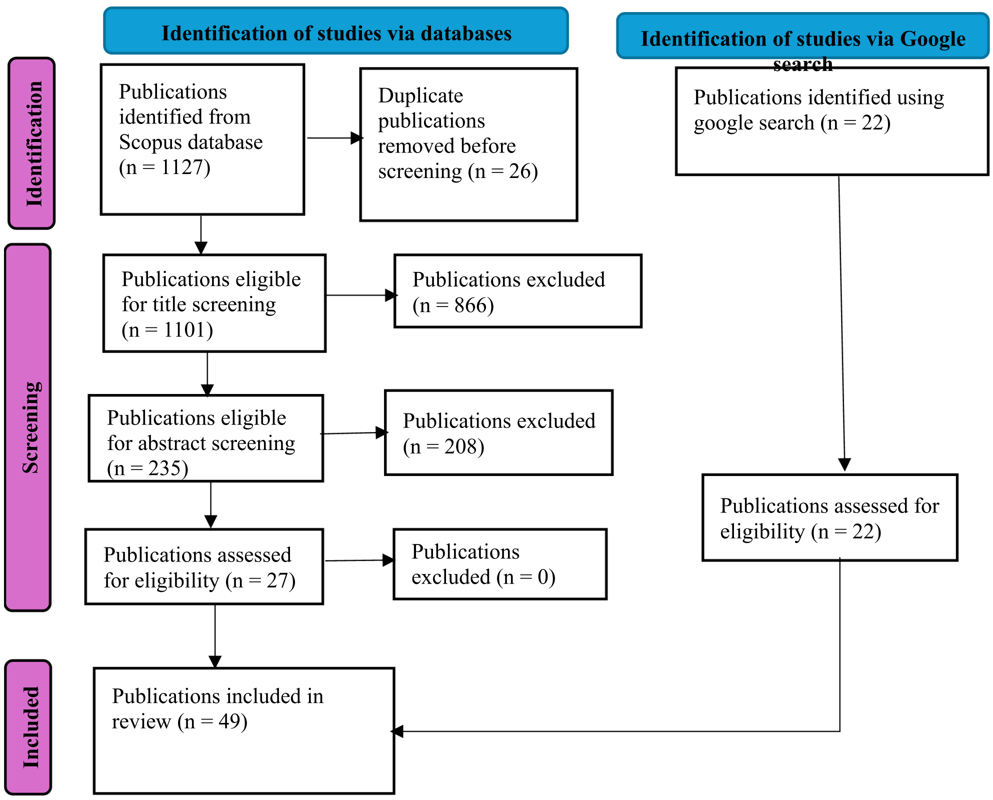


FIGURE 2
PRISMA flowchart showing the process applied to select the reviewed articles.

TABLE 1 Geographical distribution of selected studies.

| Region | No. | Key themes | Countries/ Systems | References |
|---|---|---|---|---|
| Asia | 18 | Traditional Ecological Knowledge (TEK), agro-ecological systems, irrigation, crop diversity, medicinal plants, and climate adaptation | India, Nepal, China, Taiwan, Indonesia, Sri Lanka, Multi-country | Abeywardana et al. (2019), Ahirwar and Khan (2023), Ba et al. (2018, 2023), Bai et al. (2024), Bisht (2020), Chaudhary et al. (2025), Das et al. (2023), Elfis Titisari et al. (2024), Husain and Sundaramari (2018), Kurmi et al. (2022), Liu and Ba (2024), Liufu et al. (2023), Negi et al. (2025), Ray et al., 2023, Saha et al. (2021), Saxena and Rao (2023), Sharifian et al. (2023) |
| Americas | 16 | Milpa system, agroforestry, dryland agriculture, cassava and potato systems, swidden agriculture, forest harvesting, and other crops | Mexico, Colombia, Ecuador, Brazil, Chile, USA, Peru | Aguilera-Lara et al. (2023), Benrey et al. (2024), Brinkman et al. (2022), del Castillo and Rivera-García (2022), Ebel et al. (2024), Fernandes et al. (2022), Fonteyne et al. (2023), Garavito et al. (2021), Johnson (2023), Kapayou et al. (2023), Mera-Andrade et al. (2018), Orozco-Ramírez et al. (2019), Pacheco-Trejo et al. (2022), Root-Bernstein et al. (2022), Rosero Alpala et al. (2020), Schritt et al. (2020) |
| Africa | 7 | Indigenous crops, climate-smart farming, yam systems, TEK, mushrooms, and medicinal plants | Zambia, Zimbabwe, Uganda, Guinea, South Africa | Condé et al. (2024), Merchant et al. (2023), Mwadzingeni et al. (2021), Okoronkwo et al. (2024), Semenya and Maroyi (2020), Wendiro et al. (2019), Yanou et al. (2023) |
| Oceania | 3 | Indigenous agro-ecology, land stewardship, dryland systems | Hawai'i | Lincoln et al. (2018), McGuire et al. (2025), Sirabis et al. (2022) |
| Europe | 2 | Traditional fire and irrigation systems | Portugal, Italy | Bocco (2023), de Oliveira et al. (2023) |
| Global | 3 | Global Indigenous food systems | Global (Europe, Asia, America) | Cairns (2007), Food and Agricultural Organization of the United Nations (2021), Megdiche-Kharrat et al. (2020), Sharifian et al. (2023) |

Asia exhibited the highest concentration of studies, reflecting both the region's rich agricultural heritage and the persistence of traditional farming systems across diverse agro-ecological zones. Studies from this region predominantly focused on mountainous systems in the Himalayas and southwestern China, rice-based systems in South and Southeast Asia, and traditional irrigation management. The emphasis on TEK and climate adaptation strategies was particularly pronounced in Asian studies, with 14 of 18 studies addressing these themes.

The Americas showed strong representation of Mesoamerican polyculture systems, particularly the milpa (maize-beans-squash) complex, alongside Andean highland agriculture and Amazonian agroforestry systems. Studies from this region uniquely emphasised the biocultural dimensions of agriculture, with 12 of 16 studies explicitly addressing cultural and spiritual aspects of farming practices.

African studies focused predominantly on indigenous crop systems, particularly neglected and underutilised species, and climate-smart adaptations to increasing environmental variability. The nutritional dimensions of traditional vegetables received particular attention in this region.

Oceania, although numerically limited, provided critical insights into dryland management systems and the integration of Indigenous governance structures with agricultural practices, particularly through a case study from Hawaii.

Europe was notably underrepresented, with only two studies documenting traditional irrigation systems and fire management practices, suggesting either a genuine scarcity of persisting traditional systems or a research gap in documenting European agricultural heritage.

The geographic distribution reveals important research biases: regions with strong Indigenous rights movements and international development attention (Latin America, South Asia) are better represented than areas where traditional agriculture may be equally important but less visible in academic literature (e.g., Central Asia, Middle East, parts of Eastern Europe).

## 3.2 Geographical and agroecological context

The IPLC farming systems exist across a wide range, from mountains to plains, spanning elevations from sea level to over 3,500 m and climates ranging from humid tropics to continental cold zones, illustrating ecological sophistication and locally adapted practices that promote resilience and sustainability (Table 2).

An important aspect of IPLC farming systems is the application of different practices demonstrating the adaptive sophistication of traditional agricultural systems and their capacity to produce food under conditions often considered marginal for modern industrial agriculture (Table 3).

A critical pattern emerged across all agro-ecological zones: these systems are predominantly small-scale (typically 0.5–5 ha per household) and highly labour-intensive. While eight studies mentioned labour requirements, only two (Bisht, 2020; Orozco-Ramírez et al., 2019) provided quantitative data, showing 150–300 person-days per hectare per year, compared to 10–20 for mechanized systems. This labour intensity, combined with demographic shifts, represents a fundamental constraint to scaling these systems that is inadequately addressed in most literature.

## 3.3 Research methodologies applied in reviewed studies

The reviewed studies employed diverse methodologies reflecting the interdisciplinary nature of IPLC farming systems. Ethnographic

TABLE 2 Type of IPLC farming systems by geographic location.

| Farming system type | Geographic location | Key characteristics | Representative studies |
|---|---|---|---|
| Tropical and subtropical systems | Amazon (Brazil, Colombia, Ecuador), African tropics, Indonesian peatlands, Mexican cloud forests. | High biodiversity, complex species interactions, agroforestry, and swidden cultivation. | Condé et al. (2024), del Castillo and Rivera-García (2022), Elfis Titisari et al. (2024), Fernandes et al. (2022), Garavito et al. (2021), Mera-Andrade et al. (2018), Mwadzingeni et al. (2021), Okoronkwo et al. (2024) |
| Mountain and highland systems (1,000–3,500 m) | Himalayas (India, Nepal), Andes (Colombia), Mexican Mixteca Alta, Taiwan. | Terracing, crop diversity, steep slope management, soil conservation, and high elevation adaptation. | Ba et al. (2018, 2023), Bisht (2020), Chaudhary et al. (2025), Das et al. (2023), Kurmi et al. (2022), Negi et al. (2025), Orozco-Ramírez et al. (2019), Rosero Alpala et al. (2020), Saha et al. (2021) |
| Arid and semi-arid systems | Hawaii (dryland zones), Oaxaca (Mexico), Oman, and Mexican arid regions. | Moisture conservation, drought-tolerant crops, traditional irrigation, and water harvesting. | Lincoln et al. (2018), McGuire et al. (2025), Megdiche-Kharrat et al. (2020), Orozco-Ramírez et al. (2019) |
| Coastal and wetland systems | Hawaii (coastal zones), Indonesia (peatlands), Northeast India (floodplains), Sri Lanka (water-storage/tank systems). | Rice-fish integration, wetland agriculture, coastal resource management, and tank irrigation. | Abeywardana et al. (2019), Das et al. (2023), Elfis Titisari et al. (2024), McGuire et al. (2025) |
| Temperate and boreal systems | Alaska (USA), Portugal, and Switzerland. | Subsistence harvesting, fire-based management, alpine irrigation, seasonal adaptation. | Brinkman et al. (2022), de Oliveira et al. (2023), Megdiche-Kharrat et al. (2020) |

methods—including participant observation, interviews, focus groups, and oral histories—dominated ($n = 35$), providing rich insights into cultural meanings and knowledge systems (Brinkman et al., 2022; Condé et al., 2024; Garavito et al., 2021; McGuire et al., 2025; Mera-Andrade et al., 2018; Rosero Alpala et al., 2020). These were complemented by agronomic field studies, which measured yields, soil properties, and productivity (Bisht, 2020; Fonteyne et al., 2023; Merchant et al., 2023; Sirabis et al., 2022). Several integrated biophysical datasets, combined with farmers' knowledge, have also been used to compare traditional and modern practices (Bai et al., 2024; Okoronkwo et al., 2024; Wendiro et al., 2019).

Mixed-methods approaches combining ethnographic, ecological, and agronomic techniques were used by a few (Ba et al., 2023; Das et al., 2023; Lincoln et al., 2018; McGuire et al., 2025). Some studies used historical analyses and archaeological data to reconstruct past practices (de Oliveira et al., 2023; del Castillo and Rivera-García, 2022; McGuire et al., 2025). Several studies featured participatory research, involving communities as partners in design and interpretation (Garavito et al., 2021; Lincoln et al., 2018; McGuire et al., 2025).

Other approaches included literature reviews and syntheses (Das et al., 2023; FAO, 2021; Fonteyne et al., 2023; Sharifian et al., 2023), comparative studies across regions (Chaudhary et al., 2025; Mwadzingeni et al., 2021), and economic analyses of market and household economics (Condé et al., 2024; Fonteyne et al., 2023; Mwadzingeni et al., 2021).

## 3.4 Key attributes of indigenous and traditional (IPLC) farming systems

Almost all reviewed studies addressed multiple dimensions of IPLC farming systems, often integrating technical, ecological, and socio-cultural aspects. The key messages that emerged from our review were that indigenous, also referred to as traditional, farming systems are diverse, dynamic, holistic, and complex, involving interplays among crops, livestock, and nutritious foods, while sustaining soils and biodiversity, often with little or no market inputs or outputs. These systems largely support the subsistence living of IPLCs, while relying on their traditional knowledge and cultural practices (Table 4).

A synthesis of IPLC systems and practices and their benefits (Table 4) revealed that mixed farming practices were the most common focus (47 of 49 studies), documenting cultivation methods, crop management, and soil-water conservation. Traditional ecological knowledge (TEK) was featured prominently ($n = 38$), encompassing farmers' knowledge of crops, soils, climate, and pest dynamics, as well as knowledge transmission and its erosion (e.g., Das et al., 2023; Garavito et al., 2021).

Agrobiodiversity and crop diversity were highlighted in 32 studies, encompassing species and varietal diversity, as well as the conservation of genetic resources (e.g., Mwadzingeni et al., 2021; Rosero Alpala et al., 2020; Table 4). Eighteen studies mentioned various climate change adaptation strategies, focusing on farmers' capacity to utilise drought-tolerant crops, intercropping, adjusting sowing timings, and employing cover and companion crops to address climate-related threats (Chaudhary et al., 2025; Negi et al., 2025). Social and cultural dimensions comprise an integral part of these systems, mentioning gender roles, rituals, and cultural significance in almost all studies (e.g., Garavito et al., 2021; McGuire et al., 2025). Nutritional values of traditional foods were reported in 15 studies, while ecological services, including biodiversity conservation and carbon sequestration, were examined in 16 studies (e.g., Okoronkwo et al., 2024).

Several studies reported a lack of understanding of the importance of Indigenous/traditional food in policy decision-making (FAO, 2021).

TABLE 3 Diversity of agricultural practices applied in the IPLC farming systems.

| System | Practice | Region | Representative studies |
|---|---|---|---|
| Polyculture and intercropping systems, home garden and mixed systems | Milpa (maize-beans-squash), small-scale, household-level, high-diversity, women-managed farming of medicinal plants and herbs and vegetables. | Mesoamerica (Mexico, Central America), Guinea, Colombia, Kenya, India, Sri Lanka, and various regions in Africa and Asia. | Benrey et al. (2024), Bisht (2020), Condé et al. (2024), del Castillo and Rivera-García (2022), Fonteyne et al. (2023), Husain and Sundaramari (2018), Kapayou et al. (2023), Merchant et al. (2023), Mwadzingeni et al. (2021), Orozco-Ramírez et al. (2019), Semenya and Maroyi (2020) |
| Agroforestry systems | Multi-tiered canopies, tree-crop integration, tree-tea systems, agro-silviculture, silvopastoral systems. | Hawaii, Indonesia, China, Mexico, Colombia, Chile. | Bai et al. (2024), Elfis Titisari et al. (2024), Garavito et al. (2021), Lincoln et al. (2018), McGuire et al. (2025), Root-Bernstein et al. (2022) |
| Swidden cultivation | Cultivation-fallow cycles, biodiversity conservation, soil fertility restoration, and forest integration. | Northeast India, Brazil, Taiwan, Ecuador, and various tropical regions. | Ba et al. (2018), Das et al. (2023), Fernandes et al. (2022), Schritt et al. (2020) |
| Integrated crop-livestock systems | Nutrient cycling, manure production, silvo-pastoral systems, and mixed farming. | Sub-Saharan Africa, Asia, Chile, India, and various pastoral regions. | Bisht (2020), Liufu et al. (2023), Okoronkwo et al. (2024), Root-Bernstein et al. (2022), Sharifian et al. (2023) |

## 3.5 Economic values of indigenous and traditional food systems

While most IPLC farming systems operate primarily on a subsistence basis, 24 reviewed studies show that they also contribute economically through the production of marketable crops and niche commodities. Common food crops reported across multiple regions include rice, maize, beans, yams, cassava, potatoes, and squash (e.g., Mwadzingeni et al., 2021; Rosero Alpala et al., 2020). In Colombia, native potatoes and Amazonian fruits have demonstrated increasing value in local and regional markets, primarily due to consumer preferences for organic and culturally significant crops (e.g., Garavito et al., 2021; Rosero Alpala et al., 2020). Market participation and viability were addressed in 24 studies (e.g., Condé et al., 2024; Mwadzingeni et al., 2021). Several studies noted the economic significance of non-timber forest products such as medicinal plants, fibres, resins, and honey, which IPLCs harvest sustainably using traditional management practices (FAO, 2021).

Beyond market value, IPLC farming systems generate substantial non-market economic contributions by reducing household expenditure on food, medicine, fibre, and fuel. Reciprocity systems and labour exchange networks reduce dependence on cash economies and enhance community resilience (Sangha et al., 2014; Pretty, 2008). For example, the nutritional values of traditional foods were reported in 15 studies (e.g., Mwadzingeni et al., 2021), while ecological services, including biodiversity conservation and carbon sequestration, were examined in 16 studies (e.g., Okoronkwo et al., 2024). In summary, the key marketable and non-marketable products and services include:

1) Marketable products are often small-scale and locally traded:

This includes food (grains, yams, maize, beans, squash), fibres, fuelwood, livestock, medicinal plants, and niche commodities (e.g., turmeric, yams, traditional vegetables).

Typically, there is poor financial viability, which is further limited by intermediaries and low institutional support.

2) Non-market values unrecognised in conventional markets:

This includes nutritional, diverse, and cultural values of food, health benefits, social and labour cooperation, contributions toward ecological restoration, biodiversity conservation, and climate regulation, which are vital for human and societal well-being but not valued in the market. Often, these aspects are highly valued by locals but undervalued by governments or policy decision-makers in terms of support.

The reviewed studies show that subsistence production remains a cornerstone of economic security for IPLC households, particularly in remote regions where market access is limited or unreliable (FAO, 2021; Asai and Antón, 2024). By sustaining livelihoods through both market and non-market pathways, IPLCs' farming systems contribute directly to food sovereignty, cultural continuity, and ecological sustainability.

Although seven studies referenced the need for "true value" assessments using frameworks like TEEB (The Economics of Ecosystems and Biodiversity), only two attempted multi-capital assessments. None provided comprehensive economic comparisons of IPLC and modern systems using full cost–benefit analysis in the same location.

## 3.6 Social and cultural dimensions

IPLC farming systems are deeply intertwined with cultural identity, spiritual rituals and practices, and social organisation, making agriculture more than an economic activity (Aguilera-Lara et al., 2023; FAO, 2021; Garavito et al., 2021; McGuire et al., 2025). Social and cultural dimensions, including gender roles, rituals, and cultural significance, were mentioned in 28 studies (e.g., Garavito et al., 2021; McGuire et al., 2025). Knowledge transmission occurs primarily through oral traditions and experiential learning, with elders—especially women—playing a pivotal role in seed selection, crop management, and cultural practices (Garavito et al., 2021; Rosero Alpala et al., 2020).

TABLE 4 A synthesis of indigenous and traditional agricultural systems.

| Key attributes of indigenous and traditional farming systems | Key practices/systems | Ecological and/or cultural benefits |
|---|---|---|
| Integrated and systems-based approaches | Integrated farming systems (IFS) combining crops, livestock, forests, and water; home gardens; agroforestry; agrosilvo-pastoral systems and mixed crop–livestock systems.<br>Common practices include: intercropping, mixed cropping, rotation, use of organic manure, pest and weed management through biodiversity; use of fruit trees for multi-tiered cultivation and to support vines (such as yam). | Promotes ecological balance, soil fertility, sustains soil nutrients over time, controls pests and weeds naturally, enhances pollination, and maintains ecosystem functions.<br>Improve nutrition, support household food security, maintain cultural cuisine heritage and improves local economies.<br>Such a systems also improves on-farm biodiversity conservation, and supports sustainable livelihoods through resource integration and recycling. |
| Agrobiodiversity and crop diversity | Milpa system (maize–beans–squash polyculture); yam cultivation (varietal diversity in Guinea); traditional vegetables/crops (okra, amaranth, African eggplant, nightshade, etc.); cultivation of multiple crop species in mixed farming systems. | Enhances resilience to pests, diseases, and climate variability; maintains genetic diversity and food/nutritional value; reduces chemical inputs and their dependency as largely the traditional (mostly native/naturalized) systems require little or no inputs. |
| Swidden/slash-and burn cultivation | Clearing forests/tree areas to plant crops, largely practised in tropical and mountainous regions | Balances ecosystem regeneration cycles; provides food and cultural continuity but under threat from industrial and population expansion |
| Soil and water management | Terracing, mulching, low tillage, composting, organic compositing and manuring, slash-and-burn /swidden/shifting cultivation to restore soil nutrients, gravity flow irrigation, and sometimes modern tubewell/ tank-based irrigation. | Improves soil moisture and fertility, mulch provides protection from sun to emerging crop, reduces erosion, supports water conservation, and regulates soil microclimate. |
| Climate adaptation and innovation | Adoption of drought-tolerant hybrid varieties of crops; diversification and intercropping; crop rotation; adjustment of timings for sowing a crop and adjustments of crop varieties; afforestation and agroforestry for carbon sequestration. | Builds adaptive capacity to climate change; maintains productivity and ecological stability; supports sustainable intensification. |
| Social and cultural dimensions | Collective labour, practice and transmission of traditional knowledge and kinship-based knowledge exchange, ritual-agricultural practices, community sharing of resources, often food crops grown will have significant cultural values such as rice, maize to be used on certain occasions. | Strengthens social cohesion, harmony, cultural understanding and values, preserves cultural identity, and supports knowledge transmission to future generations.<br>Indigenous practices embody adaptive management; integrates food-related ecological, spiritual, and social dimensions that helps young generation |
| Traditional knowledge and innovation interface | Combining indigenous knowledge with modern techniques—e.g., integrating hybrid varieties, improved irrigation and/or fertilizers, while retaining traditional diversity of crops and cultural values associated with certain crops. | Demonstrates co-adaptive innovation; maintains and supports traditional wisdom while improving productivity and resilience. An integrated approach can help us reinforce collective stewardship, water and land governance, and moral-ethical resource care. |

Rituals and ceremonies mark agricultural transitions, embedding ecological knowledge and reinforcing community cohesion. Examples include cassava planting rituals in Amazonian communities (Mera-Andrade et al., 2018), cultural protocols in Hawaiian restoration (Lincoln et al., 2018; McGuire et al., 2025), and lunar-based planting calendars in Mexico and Ecuador (Aguilera-Lara et al., 2023; Mera-Andrade et al., 2018). These practices often encode ecological principles, such as soil moisture dynamics, crop diversity, and pest cycles.

Collective labour systems—such as gueza in Mexico and minga in the Andes—mobilise community resources for tasks like planting and irrigation maintenance, strengthening reciprocity and social capital (Orozco-Ramírez et al., 2019; Rosero Alpala et al., 2020). Similar labour systems also existed in traditional north Indian farming systems, which have now largely disappeared due to mechanisation. Kinship-based networks facilitate knowledge exchange and adaptation (Bisht, 2020; Chaudhary et al., 2025). Customary governance systems, including Hawaiian moku and ahupuaʻa divisions, as well as Rukai land institutions, regulate resource use and maintain ecological balance (Ba et al., 2018; Ba et al., 2023; McGuire et al., 2025).

Multiple studies reported that traditional agricultural practices embody ancestral knowledge transmitted orally through generations, reinforcing social memory, identity, and belonging (FAO, 2021; Garavito et al., 2021). Ritualised sowing and harvesting practices, as documented in Amazonian Shagra systems, are embedded in spiritual cosmologies that frame farming as a reciprocal relationship between humans and the land (Garavito et al., 2021; Mera-Andrade et al., 2018). Such practices are not merely economic activities, but rather expressions of Indigenous sovereignty and responsibilities as guardians of the land.

Cultural values tied to farming are also reflected in language, with agricultural terminology serving as a repository of ecological knowledge and cosmology (FAO, 2021; Cairns, 2007). Indigenous agriculture was shown to enhance social cohesion through collective labour systems, rotational work groups, and communal resource governance and knowledge sharing. Rosero Alpala et al. (2020) reported that Indigenous women play central roles in seed selection and knowledge transmission, reinforcing familial cooperation and intergenerational continuity. Studies from North America have further demonstrated that engagement in traditional food harvesting and cultivation is associated with improved mental health and reduced suicide risk, highlighting the deep psychosocial importance of Indigenous farming systems (FAO, 2021; Kapayou et al., 2023).

## 3.7 Governance, economic issues, and other challenges

While the main focus of the review was on the farming practices of IPLCs, we also attempted to examine the role of local governance mechanisms in this context. Out of 49 studies, 19 mentioned the role of governance and institutional factors, covering customary tenure and policy contexts (FAO, 2021). Typically, IPLC farming systems are community-based and largely managed by the community, under the auspices of local social institutions. Women are central to seed saving, diverse food systems, nutrition, and household-level farming, yet they are highly vulnerable during economic transitions and migration. Particularly, when men have to leave home for economic reasons to work, women play a major role in managing the farm and household. These gender disparities exacerbate vulnerabilities, and women largely remain marginalised in policy and extension systems despite their critical roles (e.g., Chaudhary et al., 2025; Garavito et al., 2021).

IPLC farming systems face significant challenges, as 41 studies have reported knowledge erosion, migration, market pressures, and policy gaps. Several studies have mentioned threats, such as youth migration, which disrupts intergenerational knowledge transfer, and cultural erosion driven by modernisation and perception biases against traditional practices (e.g., Abeywardana et al., 2019; Negi et al., 2025). Climate change is a common factor affecting IPLCs systems across the globe. Despite these challenges, the IPLC farming systems are invaluable for offering agro-ecological, human health, and conservation benefits, which yet need to gain full recognition among mainstream society, particularly policymakers.

Only 12 studies addressed revitalisation efforts, such as initiatives to support the continuation, adaptation, or revival of traditional practices (e.g., Fonteyne et al., 2023; Pacheco-Trejo et al., 2022).

## 3.8 Research gaps

The literature reveals several major gaps that hinder a comprehensive understanding of IPLC farming systems. In terms of productivity and efficiency, only eight studies provided quantitative yield data that could be compared to modern systems, and just two assessed labour productivity. Measures of resource use efficiency—such as water and nutrient use—were rarely included, and no study conducted a full total factor productivity analysis.

There is little to no analysis of what proportion of global food systems could realistically rely on traditional or hybrid methods. Neither are there any studies on comparing the long-term, socio-ecological and economic performance of contemporary and traditional systems in any one region.

Few studies investigate why certain traditional practices disappeared, often attributing decline solely to external pressures without considering internal limitations. External and internal pressures such as colonization, industrialization, and commercialisation and their related policies and programs have played a significant role in the 'dysfunctioning', 'disruption' and/or demise of traditional systems. Revival efforts are rarely critically evaluated, and the constraints to adoption by modern farmers are insufficiently studied.

While gender relations are mentioned in 14 studies, only three offer critical analysis. Class, caste, and ethnic differentiation within communities are examined in just two studies, and generational conflicts over farming decisions are noted but not systematically explored.

There is limited insight into what level of policy support is necessary or how to understand the true value of traditional farming. Mechanisms for compensating ecosystem services remain underdeveloped. Finally, integration mechanisms between traditional and modern systems are inadequately documented.

# 4 Discussion

This paper highlights the importance of IPLCs' farming systems for applying ecologically sustainable, fine-scale knowledge and practices to grow diverse, nutritious, and climate-adaptive crops, befitting different geographical regions, which can help inform modern, mainstream farming systems (FAO, 2021; Ritchie et al., 2022; Abdo et al., 2024). The IPLCs' agro-ecological systems are typically community-based, involving fine-scale management of both crops and livestock, intertwined with socio-cultural values to support the livelihoods and wellbeing of people.

IPLC farming systems typically apply agroecological principles for cultivating diverse crops and conserving biodiversity, soil and water resources, as demonstrated in Tables 3 and 4. This aligns with the Agroecology Living Lab (ALL) approach (mainly popular in Europe; https://www.ae4eu.eu/read-more-living-lab/), where the focus is on co-creation, in-situ testing, and the implementation of sustainable farming practices to transform modern agricultural systems (Stone et al., 2025). The ALL approach promotes context-specific transition, integrating modern and traditional techniques. Effective collaborations between these two systems can help transition modern farming at a large scale, in particular, small-scale farms across the Asia-Pacific offer a great opportunity (Rastorgueva et al., 2026).

However, the role and value of IPLC farming systems are often ignored and underestimated in policy-making, primarily because many of their benefits do not translate into the market (Sangha, 2014, 2021). In contrast, the mainstream/modern agricultural systems produce is targeted at markets, with a focus on quantity (rather than quality, diversity, and nutritional values) and a heavy reliance on external inputs (Abdo et al., 2024; Ritchie et al., 2022). Several studies that we reviewed highlighted the market value of local produce, but even that value reflects only a small fraction of the total value of produce from IPLC systems, which deliver a range of health benefits and ecosystem services such as soil conservation, carbon sequestration, biodiversity protection, and water conservation. Warltier et al. (2021) estimated the economic value of Indigenous "country" food (defined as subsistence-focused provisioning based on hunting, fishing and collecting local wild animals and plants) for Nunavut communities in Canada at CA$198 million/year, just for energy and protein values (excluding cultural or social values). Most importantly, the cultural values, traditions and norms linked with sowing, harvesting, and processing local foods shape IPLCs' identities, stories, and societies. For example, rice is known as a staple food for many Asians, with a direct market value; importantly, it is also considered a symbol of life and prosperity in many religious and cultural ceremonies—a value that can not be measured. A significant gap identified in this review is the lack of studies that highlight the true value of IPLC systems.

A lack of understanding of the importance of IPLC systems further leads to equity issues. Modern agriculture is significantly subsidised by government policies, especially for the use of fertilizers and pesticides/herbicides, while traditional farming systems are being ignored and undermined. The total value of such subsidies exceeds USD 635 billion per year (Gautam et al., 2022; Damania et al., 2023; Hayden and Hayden (2025). A detailed study by Barbier (2025) suggests repurposing current agricultural subsidies to support environmentally friendly agricultural practices. Drucker et al. (2023) proposed developing incentivised mechanisms to preserve agrodiversity and described a successful community-level case study from Malawi.

How can we assess the true value of IPLC farming systems to inform policy decision-makers and the public? The Economics of Ecosystems and Biodiversity (TEEB) report (2018), led by the UNEP on agrifood systems aims to refine the metrics used to measure food systems by applying a holistic approach. Chapter 2 of the same report (by Zhang et al., 2018) proposes a holistic framework for food systems, accounting for natural, social, human, and produced capitals. The IPLCs' agro-ecological farming systems rank highly in the first three categories for conserving nature, enhancing social cohesion and wellbeing, and human capital for uplifting people's knowledge and skills—all non-marketable—and low for the 'produced' capital—marketable (mainly for sustenance purposes). In contrast, modern farming systems score highly for 'produced' capital, which is reflected in the market, but very low on the other three capitals that are non-marketable yet underpin the production system. Applying a metric of four capitals to measure the performance of agro-ecological systems can inform policymakers to invest in supporting IPLC systems.

Currently, IPLC farming systems are rapidly declining due to a range of external pressures and threats, exposing both IPLCs and the broader population to significant risks and challenges (Table 5). A startling dominance of existing industrial food systems, which largely operate at the economies of scale and with substantial subsidies; lack of awareness and education among the public about the importance of traditional foods; lack of government support for the IPLC food systems; and disconnect between food systems, human health and wellbeing, climate and policy actions were well highlighted by Webb et al. (2021).

TABLE 5 Drivers of change for the IPLC farming systems and related challenges.

| Drivers | Challenges/risks |
|---|---|
| Industrial agriculture expansion, mechanization and commercialisation | • Simplification of productive landscapes to promote monoculture of main crops (wheat, rice and maize)<br>• Government subsidies on chemical inputs<br>• Commercialisation of crops<br>• Loss of traditional, local food varieties<br>• Loss of traditional farming knowledge |
| Market pressures | • Increasing population and demand for main cereal crops<br>• Food security<br>• Erosion of cultural and ecological knowledge<br>• Youth migration to urban areas<br>• Poor understanding of the importance of traditional foods |
| Institutional and policy neglect | • Lack of recognition and incentives for Indigenous/traditional farming<br>• Insufficient financial support and policy programs<br>• Marginalisation of IPLCs in agricultural extension systems |
| Climate variability (change in rainfall patterns and frequency, floods, droughts, etc.) | • Shift to hybrid and chemical-based farming<br>• Poor performance of traditional systems<br>• Unexpected pest/weed infections<br>• Increased vulnerability of traditional varieties |
| Biasness toward modern varieties | • Decline in demand for traditional foods<br>• Higher yields of hybrid varieties<br>• Mechanisation promoting large-scale farming<br>• Perception that traditional farming is backward or inefficient |
| Knowledge erosion and social change | • Disruption of intergenerational knowledge transfer<br>• Loss of TEK<br>• Gender disparities and marginalisation of women's roles<br>• Weakening of customary governance institutions<br>• Cultural erosion and loss of agricultural rituals |

To mitigate the above challenges and risks, urgent action is needed to support traditional systems, including reviving knowledge, skills, and implementing culturally appropriate incentivising mechanisms and policy programs to restore IPLC farming systems (Drucker et al., 2023; Zimmerer and de Haan, 2017). Globally, recognition of IPLC food systems is beginning to emerge, for example, the FAO initiative on Globally Important Agricultural Heritage Systems.[1] But, the financial investment and government support are yet to follow (International Network of Mountain Indigenous People (INMIP), 2021; von Braun et al., 2021). Recently, broader investments in supporting IPLCs efforts were highlighted by the United Nations Global Biodiversity Framework Fund, ratified at the 7th Assembly of the Global Environment Facility, to invest 20% of its resources to directly support IPLC' initiatives to protect and conserve biodiversity. Yet, strong financial support directly for the IPLC food systems is largely missing, mainly due to the prevalent and dominant corporate culture of existing industrial food systems (Canfield et al., 2021). Cognizant of the social and environmental problems of the current food systems, the UN Secretary-General organized a high-level UN Food Systems Summit (UNFSS) in Sept 2021 to emphasize transforming the current food systems that are responsible for 1/3rd of global GHG emissions and to develop equitable and sustainable food systems that offer food security and nutrition for all (Canfield et al., 2021), and the local, Indigenous and native food systems were the highlight for this change.

The IPLC farming systems can be the *game-changer* for global food sustainability, security, nutrition, and resilience for offering:

- Local, fine-scale models of sustainable, climate-adaptive, resilient farming systems that preserve biodiversity, soil health, water systems, and ecosystem processes and functions.
- Dietary diversity, nutritional food, and improved human health (including food security in challenging conditions).
- Integrated ecological health, human health, cultural/spiritual values, and rejuvenated community sense with sustainable farming systems.

Some initiatives in the past have proven useful in supporting IPLC systems, such as microfinance or social finance schemes (International Fund for Agricultural Development – https://www.ifad.org/en/web/operations/-/project/1100001284), local community initiatives, and others. Community-led initiatives such as 'seed banks' or 'slow food' movements are also becoming common. Seed banks are typically aimed at saving plant diversity, seeds as genetic pools, that may be useful in future research while 'slow food' movements promote local, authentic, and conscientious production, preparation and consumption of food. In India, a farmer-led local organisation, Navdanya, is actively working to preserve the biological and cultural diversity of food systems in 22 states, with more than 150 community seed banks to support the production of local, authentic/culturally relevant, and chemical-free food systems.[2] Establishing IPLC-based, self-governed organisations and cooperatives with networks across the loca, regional and national scales can help progress the IPLCs as well as update modern farming systems at a faster rate and wider scale while equally meeting Sustainable Development Goals (1, 2, 3, 13–17) and affording equitable, sustainable, economically viable, nutritious and resilient food systems for the global populations.

1 https://www.fao.org/giahs/en
2 https://www.navdanya.org

# 5 Conclusion

This review of 49 studies on IPLC farming systems reveals that these systems are ecologically rich and culturally embedded, featuring high agrobiodiversity, integrated production, and advanced resource management. They effectively conserve soil, reduce pest damage, and maintain crop diversity, yet face serious threats including knowledge loss, economic marginalisation, youth out-migration, policy bias, and climate stress. While descriptive and functional benefits are well-supported by evidence, broader claims about sustainability and scalability lack empirical rigour. Most studies do not compare IPLC systems with modern agriculture or provide quantitative productivity data, highlighting a gap between advocacy and evidence.

This review presents the first comprehensive synthesis of IPLC farming systems. It highlights the "diversity-yield trade-off," where high agrobiodiversity comes with 20–40% lower crop yields, a tension often overlooked in policy debates. Rather than framing IPLC and modern agriculture as opposites, the review proposes an integration approach, showing that hybrid systems—combining traditional techniques with modern practices—can deliver multiple benefits and ALL approach, as mentioned earlier, can help realize this opportunity at a large scale. The review identifies key knowledge deficits, including a lack of productivity comparisons, economic analyses, scalability studies, and failure assessments, and highlights geographic and temporal biases in the literature. Finally, it recommends applying TEEB's agro-ecosystems framework to better understand IPLC contributions beyond conventional economic metrics.

To support IPLC farming systems, policymakers must reallocate agricultural subsidies toward agroecological and traditional practices, introduce payments for ecosystem services, and eliminate harmful subsidies that disadvantage traditional methods. Given the rapid loss of knowledge, urgent action is needed to document and transmit traditional knowledge through education, elder engagement, and youth programs. Synthesis efforts should produce meta-analyses that integrate social, ecological, and economic aspects, and decision-support tools to guide context-specific applications—recognising the urgency as IPLC systems and knowledge are disappearing faster than they can be studied.

# Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

# Author contributions

KS: Conceptualization, Formal analysis, Investigation, Supervision, Writing – original draft, Writing – review & editing. SL-F: Formal analysis, Investigation, Writing – original draft, Writing – review & editing. GK: Formal analysis, Methodology, Writing – review & editing. RA: Investigation, Writing – review & editing. SD: Formal analysis, Writing – review & editing.

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## Publisher's note



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